# PATENT SPECIFICATION

(11) 1 434 173

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(21) Application No. 26708/74 (22) Filed 17 June 1974
(31) Convention Application No. 2 331 467
(32) Filed 20 June 1973
(31) Convention Application No. 2 348 211
(32) Filed 25 Sept. 1973
(31) Convention Application No. 2 354 229
(32) Filed 30 Oct. 1973 in
(33) Germany (DT)
(44) Complete Specification published 5 May 1976
(51) INT CL.[2] B23B 51/08
(52) Index at acceptance B3C 1B6A3 1B6G 1B6H 1B6M 1B6N

(19)

## (54) IMPROVEMENTS RELATING TO THE DRILLING OF HOLES

(71) We, STUMPP & KURZ, of 7 Stuttgart 80, Liebknechtstrasse 7, Federal German Republic, a Kommanditgesellschaft organised and existing under the laws of the Federal German Republic, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to drilling tools for, and methods of drilling, a hole of the kind having a cylindrical first zone and a second zone on a common axis therewith, said second zone being joined to an open mouth of the hole by said first zone, and the second zone being divergent away from the first zone. Such a hole will be referred to herein as a "hole of the kind hereinbefore specified".

Such holes are formed in an element which is commonly a construction element such as a wall or floor of a building.

The use of such holes in construction elements for the fastening of anchoring devices is known. The divergent hole zone serves as a form-closed abutment and support for a portion of a plug or other anchoring device, e.g., for a casing of the device spread upon an expanding element thereof which thus resists extraction. The extraction force is determined by this support and not by frictional force, as would be the case where the expanded or spread casing of the anchoring device is merely pressed against the wall of a cylindrical hole. This last-mentioned, very common plug type of anchoring device presents the disadvantage that the friction contact depends very strongly on accurate drilling, accurate and expert fastening of the plug and on the properties of the material of the construction element. Furthermore, it may become detached in the case, for example, of vibration. To eliminate such difficulties, holes of the kind hereinbefore specified and anchoring devices adapted therefor are commonly employed.

Many methods for drilling or boring such holes and corresponding drilling tools have been proposed. Typically, in such methods a cylindrical hole is first bored by means of a standard drill or borer, and then a separate, special boring tool is used for boring out the conical zone of the hole. In one such method, a conical guide element is then inserted in the first (cylindrical) hole, and boring elements are slid over the external casing surface of the said guide element and forced radially outwards, so that a conical hole can be bored.

Some of the drilling tools associated with these methods are constructed in such a way that their boring or cutting elements are situated on the outside of an insert that remains in the hole after the boring process. During boring of the conical hole zone, they are for example expanded by driving or hammering a cylindrical expanding element into an opening of the insert which diverges conically in the boring direction. This arrangement presents the disadvantage that the penetration of the insert, which remains in the hole and serves then as fastening element, cannot be exactly determined. The extent of such penetration depends upon the strength of the material. Moreover, the position of this boring element cannot be checked, and such a tool is likely to function satisfactorily only when precise adjustment of the axial impact force applied during boring, relative to applied torque, has been made. If the impact is too strong, the tool can become jammed; if it is too weak no further boring of the hole takes place. A certain amount of play is always present on the casing surfaces in the conical hole zone, since the portion which remains in the hole has been used as boring tool; and such a method is relatively expensive since a new drilling tool must be employed each time.

It has been proposed to provide pivotable bits arranged in the manner of scissors at the point of drilling or boring shaft; these bits are forced radially outwardly by centrifugal force during boring. This is an example of a

method in which the boring tool remains in the hole after the boring or drilling process and itself acts on an anchor; it presents the difficulty that the shaping of the conical hole zone, after the boring process but before insertion of the plug, cannot be controlled.

In one previously-proposed method, wherein boring elements are slid on by way of a conical guide element inserted in a cylindrical hole, the process involved is, practically speaking, not a cutting process but a reaming process. Here, too, it is difficult to determine whether the maximum area which can be achieved has in fact been bored out. Furthermore, the zone of the cylindrical hole nearest its mouth, drilled out with a standard drill as a first stage of the drilling process, must be accurately formed since it determines the position of the conical guide element of the tool provided especially for boring the conical zone. In the said method, the divergent zone is not conical but funnel-shaped, i.e., with a curved generatrix; this requires a plug of special, soft construction.

Another previously-proposed drilling tool and method operates in such a way that first a normal hole is bored and then the tool bit is replaced. This method is based on the principle that the resistance of the material to the replacement bit of the boring element is so great that the bit is stationary at first and is then displaced until it strikes a stop. To accomplish this result, the boring resistance which the material offers to the material of the bit must be greater than the pressure, in the direction of advance, of a spring of the tool. It is very doubtful whether such a tool (intended for blast holes) can be employed at all in holes for plugs.

Eccentric borers have been proposed which are inserted, without a guide, in a cylindrical hole for boring a conical zone therein. In these devices an asymmetrical cutting block is provided at the end of a rod. The latter must of necessity be relatively weak; and when the cutting block is rotated in the hole, it executes, without any guide, a circular path to cut into the wall of the previously-formed cylindrical hole. Here only a very inaccurate conical zone can be bored. Support of the asymetrical cutting block by means of the rod is highly susceptible to rupture, and the cylindrical hole which is to be drilled first must be relatively large.

In yet another drilling tool and method proposed herebefore, whilst a body provided with a slanting groove is rotated in a cylindrical hole a boring cutter, which is initially inserted in the groove so as to be in alignment with the periphery of the body, is pulled out by a spring in a direction opposite to that of advance of the tool. The boring cutter is so constructed that its cross-section undercuts the cylindrical hole. Operation of such a tool is extremely complicated; the danger of rupture in the very weak boring cutter is again present, and the possible extent of the undercut depends on the ratio of the spring force to the strength of the material.

Disadvantages present among these previously-proposed methods and tools can be summarized as follows.

(a) Two boring process with different tools are necessary.

(b) The support of the actual cutting parts of the tool, when they move radially, it too weak.

(c) Wear (in relation to the length of the hole drilled) is extremely high.

(d) Expensive tools are involved which, when worn, must be disassembled for replacement of the actual cutting elements, and the process of disassembling is complicated.

(e) Boring of the conical area cannot be exactly controlled and depends on relationships between properties of tool elements, e.g., springs, and those of the material being worked.

(f) The means for supporting the actual cutting elements generally necessitates a very weak force-absorbing cross-section of the tool and tends to expose the cutting elements to very high applied forces which may lead to rupture.

(g) Removal of bored-out material from the hole is not accomplished during the boring process; as a result, the drilling or boring process itself and the later insertion of an expanding anchoring device and/or the introduction during drilling of a tool element to remain in the hole as part of the plug, is made more difficult.

According to the invention, in a first aspect, a drilling tool for drilling a hole of the kind hereinbefore specified comprises a tool body rotatable about an axis thereof; first cutting means carried by the tool body and adapted for drilling a cylindrical hole on said axis; a substantially rigid tool member carried by and rotatable with the tool body about said axis and having second cutting means, said tool member being arranged for movement with respect to the tool body between a retracted position of the second cutting means, wherein the second cutting means defines about said axis no greater radius than does the first cutting means, and a fully extended position of the second cutting means, wherein the second cutting means defines a greater radius than does the first cutting means; and actuating means carried by the tool body and arranged to effect such movement of said tool member with respect to the body to move the second cutting means from its retracted to its fully-extended position in response to progressive advancemetnt of the tool body into a said hole from a predetermined axial position therein, whereby during such advance the second cutting means can bore a said divergent second zone of the hole, a leading portion of the tool

body being of such cross-section as to be laterally supported on said axis in a first said zone of the hole behind the second cutting means during said advance, and said tool body having means for constraining said tool member in a predetermined path throughout the said movement of the tool member with respect to the body.

Preferably said actuating means and constraining means are adapted so that said movement of the tool member with respect to the tool body is rotational.

The first cutting means is arranged in the tool body itself in some embodiments of the invention.

In another embodiment, said first and second cutting means are arranged in a single cutting member adapted for drilling a cylindrical hole on the axis of rotation of the tool body when the cutting member is orientated in a first angular position relative to the tool body, being the retracted position of the second cutting means, and for drilling a hole of progressively changing diameter when the angular orientation of the cutting member relative to the tool body is progressively changed between said first position and a second angular position being the fully extended position of the second cutting means, the said cutting member being carried by said tool member, said tool member having an axis radially offset from the tool body axis and being mounted in the tool body for rotational movement about the said axis of the tool member, whereby to change said angular orientation. Preferably in this arrangement said tool member is a removable drill bit, the tool being adapted for removal and replacement thereof.

The actuating means preferably includes an actuating member movable axially on the tool body and biasing means for biasing the actuating member towards a forward position on the body, the actuating member being operatively connected with said tool member to effect said movement of the tool member with respect to the tool body in response to relative axial movement between said actuating member and tool body, the actuating member being arranged to initiate said relative axial movement in response to the tool body reaching said predetermined axial position in a hole being drilled.

Preferably said leading portion of the tool body is generally-cylindrical and of such diameter relative to the first cutting means as to fit slidingly in a cylindrical hole zone drilled by the first cutting means.

According to the invention, in a second aspect, a method of drilling in an element, in a single operation, a hole of the kind hereinbefore specified, using a drilling tool according to the invention in said first aspect thereof, comprises the steps of introducing the tool to the element; with the tool in continuous rotation about the tool body axis and the tool member in its retracted position, drilling the clyindrical first hole zone in the element by means of the first cutting means until the tool body has reached a predetermined axial position with respect to the element with a leading portion of the tool body laterally supported on said axis in said cylindrical first zone; and continuing rotation of the tool so that the actuating means thereafter progressively effects rotational movement of the said tool member with respect to the tool body from its retracted to its fully-extended position, so that during said continued rotation of the tool the second cutting means progressively bores out the divergent second hole zone with the tool body laterally supported on said axis in the cylindrical first zone.

In a third aspect, the invention provides an element, preferably a construction element, having a hole drilled therein according to said second aspect of the invention.

Embodiments of the invention will now be described by way of example only, with reference to the accompanying drawings, of which:—

Figure 1 is a cross-sectional view of a hole drilled in a construction element, in accordance with the invention;

Figure 2 is a cross-sectional view of a hole as shown in Figure 1 having fastened therein a plug or socket consisting of an expanding element and a casing;

Figure 3 is a view, partly in section, of a first embodiment of a drilling tool according to the invention;

Figure 4 is an elevation seen in the direction of the arrow IV in Figure 3;

Figure 5 is a view, partly in section, of the tool shown in Figure 3, but with a pivotable tool member thereof pivoted outwards;

Figure 6 is a view, partly in section, of a second embodiment of a drilling tool according to the invention;

Figures *7a* and *7b* are elevations, mutually displaced by 90°, of a drill bit used in the embodiment of Figure 6;

Figure *8a* is a partial front view of a drill bit holder used in the embodiment of Figure 6;

Figure *8b* is a schematic representation of the mutual engagement of individual elements in the embodiment of Figure 6;

Figure *9a* is an elevation of a body of the tool shown in Figure 6;

Figure *9b* is a cross-sectional view taken along the line IX*b*—IX*b* in Fig. *9a*;

Figure 10 is a view, partly in section, of the embodiment of Figure 6, when a hole is being drilled;

Figure 11 is a partially sectional illustration of a modification of the tool shown in Figure 6;

Figures *12a* and *12b* are illustrations corresponding to Figs. *8a* and *8b* of the modified tool of Figure 11;

Figure 13 is an elevational view of a body of the tool shown in Figure 11;

Figure 14 is an elevation, partly in section, of a third embodiment of drilling tool according to the invention;

Figure 15 is a sectional view along the line XV—XV in Figure 14;

Figure 16 is a schematic representation of a first modification of the drilling tool of Figure 14; and

Figure 17 is a schematic representation of a second modification of the tool of Figure 14.

Referring to the drawings, Figure 1 shows a hole 11, as it is to be drilled in a construction element 1 (such as a concrete wall) and be employed for the fastening of, for example, expandable plugs. It has an open mouth joined by a first cylindrical zone 12 to a divergent zone 13 which is conical and extends with increasing diameter from the zone 12 into the wall 1; and a second cylindrical zone 14 joined to the zone 13 and extending beyond it into the wall 1. The front surface of the wall 1 wherein this hole is to be drilled is marked 1′.

Figure 2 shows a plug-type anchoring device placed in hole 11 and consisting of a casing 21 and a generally-conical expanding element 22. Casing 21 is cylindrical before the insertion of the plug into the hole, and is provided with several slots extending parallel to its longitudinal axis (such slots are shown at 23 and 23′) from the left-hand end of casing 21 approximately over the same length as that of the conical hole zone 13. The portion of the casing 21 not provided with slots corresponds to the cylindrical zone 12 of hole 11. Expanding element 22 comprises a cylindrical first portion provided with an internally-threaded bore 24, and a conical portion joined thereto. The conical portion has an angle of expansion corresponding to that of the conical hole zone 13, and its largest diameter (at the left-hand end as seen in Figure 2) is essentially equal to, but typically slightly smaller than, the diameter of the cylindrical hole zone 14. To assemble the plug, the expanding element 22 is first inserted in the hole 11 to such a depth that its conical portion is situated in the cylindrical hole zone 14. The casing 21 is then inserted into the hole 11 over the cylindrical portion of the expanding element 22, and the latter is pulled into the portion of the casing 21 having the slots 23, 23′. This is achieved with the aid of an expanding tool (not shown) which has a pull rod provided with threads. The pull rod is screwed into the bore 24 of the expanding element 22 and pull is exerted on the pull rod in the direction of extraction of the plug (towards the right in Figure 2), while at the same time the casing 21 is held in the hole 11 by a pressure element or abutment of the expanding tool. Thus the slotted portion of the casing 21 is expanded by the conical portion of the expanding element in such a manner that, as shown in Figure 2, the slotted portion is conically deformed and abuts against the wall of the conical hole zone 13. By this operation the assembly of the plug is completed. Then a bolt 29 is screwed into the internal thread 24 of the element 22 to fasten any desired object to the wall 1, e.g. a plate 30. Any extraction force that acts upon the bolt 29 and thus upon the expanding element 22 of the plug presses the slotted portion of the casing 21 more strongly against the wall of the conical hole zone 13, and thus prevents extraction of the plug. The extraction force is therefore determined not by the frictional force between casing and hole, but by the properties of the material of the wall 1 against which the conical slotted portion of the casing 21 presses. The fastening of the plug is consequently as strong as the material itself and insensitive to vibration.

One embodiment of a drilling tool suitable to drill a hole 11 according to Figure 1 is shown in Figures 3, 4 and 5. The drilling tool has a tool body or shaft 40 having an essentially rectangular cross-section, and the point of the shaft is formed as a drilling cutter 41 which constitutes a first cutting means, for drilling the cylindrical hole zones 12 and 14. The leading portion of the tool body 40 is provided with a diametral through slot 42. In this slot, a tool member in the form of a blade 43 which carries a second cutting means in the form of a cutting bit 58, for boring out the conical hole zone 13, is pivotably supported by means of a pin 44, which is arranged transversely and rigidly in the tool body 40 to define a pivot axis and about which the blade 43 is rotatable in a plane containing the tool body axis, to follow an arcuate path about the pivot 44. The blade 43 has a blade element in the form of a slot 45 which extends obliquely with respect to the longitudinal axis of the tool body 40. A blade-engaging element in the form of a pin 46 protrudes into slot 45 and is rigidly carried by an actuating sleeve 47 which is displaceably arranged on the tool body 40. To make possible this displaceability of the sleeve 47 with its pin 46 on the tool body 40, and also to limit such displacement, the pin 46 extends through a further slot 48 in the tool body 40. The slot 48 extends parallel to the longitudinal axis of the tool body 40. By this arrangement, when the sleeve 47 is displaced in the direction of the arrow *H*, Figure 3, the engagement of the pin 46 with the slot 45 at one end of the blade 43 causes the other end of the blade to pivot outwardly in the direction of the arrow *K* from the retracted position of the bit 58 shown in Figure 3, towards its fully-extended position shown in Figure 5. In this retracted position, upon rotation of the tool body about its axis, the bit 58 defines a radius no greater than (and in this case equal to) that defined by the cutter 41; whilst in the position shown in Figure 5, it defines a greater radius.

Biasing means in the form of a compression

spring 50, bearing at one end in an annular groove 49 in the outer end of the sleeve 47, envelops the tool body 40 and is supported, at its other (right-hand as seen in Figures 3 to 5) end, on a flange 51 on the tool body 40. Beyond the flange 51, the tool body 40 comprises a shank 52 for holding the drilling tool in the chuck of a percussion drilling machine. The spring 50 forces the sleeve 47 into its extended or forward position, as seen in Figure 3, on the tool body 40, which position is determined by the abutment of the pin 46 in the extreme left-hand end of the slot 48. The sleeve 47 is displaceable along the tool body against the force of the spring 50, until the pin 46 abuts against the other or right-hand end of the slot 48. Openings 53 for the discharge of bored-out material (chips) are provided in the sleeve 47. A pressure ring 55 encircles and is rotatably mounted on the sleeve 47 by a retaining ring 54. This pressure ring 55 can be locked when the tool body 40 is rotated, and bears against the wall face 1'.

In the position shown in Figures 3 and 4, the sleeve 47 is in its extended or forward position. The blade 43 is of such dimensions that in this position it is retracted, i.e. completely lodged inside the slot 42, so as to lie within the width of the tool body 40.

In drilling a hole 11, a cylindrical hole is first drilled by means of the cutter 41, the blade 43 being in the position shown in Figures 3 and 4. This continues until the tool reaches a predetermined position in the hole 11, at which position the pressure ring 55 strikes the wall surface 1'. The cylindrical hole zone drilled up to that time extends into the wall 1 to such a depth that the front edge of the blade 43 is at the axial position in the hole 11 at which the hole zone 12 joins the conical zone 13.

When the tool body 40 is advanced further into the wall, a cylindrical hole continues to be drilled out by the drilling cutter 41. The pressure ring 55, and therewith the sleeve 47, are however retained at the surface 1', so that the spring 50 becomes compressed and the pin 46 is displaced in the slot 48, thereby pivoting the blade 43 from the position shown in Figure 3 outwardly towards its fully-extended position shown in Figure 5. This outward pivoting is proportional to the advance of the tool body 40 into the material of the wall 1. When the blade 43 is thus pivoted outwardly, a cutting bit 58, on the front edge of the blade 53, bores out the conical zone 13 of the hole 11. The bit 58 has a front edge 58' which acts as principal cutting edge, and a lateral edge 58" which acts as a secondary cutting edge. The conical hole zone 13 is fully formed when the pin 46 reaches the right-hand end of the slot 48 (Figure 5). Further displacement of the sleeve 47 with respect to the tool body 40 is then no longer possible.

Simultaneously with this boring out of the conical zone 13, the cylindrical hole zone 14 is completely drilled out by the cutter 41. Throughout, the tool body 40 is guided and centred in the portion of the zone 14 already formed.

When the drilling tool is being extracted, the blade 43 is retracted back into the slot 42 by expansion of the spring 50.

In the second embodiment shown in Figures 6 to 10, drilling of the conical zone 13 of the hole 11 is achieved by means of a one-piece drill bit or borer 114 (Figs. 7*a*, 7*b*), constituting a tool member in which a drilling cutter 116 is fixed. The drilling cutter 116 combines a first cutting means with a second cutting means in a single member, as will hereinafter be seen. The drill bit 114 is eccentrically supported in a tool body member or shaft 140. In this embodiment the drill bit is arranged for rotational movement with respect to the tool body, to effect radial movement of the second cutting means with increasing advance of the tool body. An actuating sleeve 147 is mounted on the body member 140 and is displaceable axially and rotatably with respect thereto. The body member 140 has an eccentric bore 142 in which the shank 112 of the drill bit 114 is rotatably mounted. The shank 112 has an extension 113 which is fixed in a rotatable element in the form of a drill bit holder 105, which is likewise rotatable with respect to, and is mounted coaxially in, the tool body member 140. A further tool body member or shaft section 106 is screwed together by threads 138, 137 respectively, with the outer end of the body member 140, to form therewith the body of the drilling tool. A push rod 108 is displaceably housed in a bore 107 of the body member 106. The latter includes a shank 152 for holding the drilling tool in the chuck of a percussion drilling machine, not shown.

The drill bit 114 has a head 111 integral with the cylindrical shank 112. The shank extension 113 has a slight conical taper, and there extends from its junction with the shank 112 a flattened face 114'. The drill bit head 111 has a slot 115 rigidly carrying the hard metal drilling cutter 116. The latter has a V-shaped leading cutting surface comprising two main cutting edges 117' and 118', and two secondary cutting edges 117 and 118. The edge 117 extends parallel to the longitudinal axis *A—A* of the drill bit 114, whilst the edge 118 is inclined to the axis *A—A* by an angle $\alpha$ which corresponds to the half-angle subtended by the conical hole zone 13. The leading point 119 of the drilling cutter 116, i.e. the centre of its leading cutting surface, is offset at a common radial distance *a* from the cutting edge 117 and from the point 120 defining the leading edge of the secondary cutting edge 118. The point 119 is, however, radially displaced by an amount *b* from the drill bit axis *A—A*.

The drill bit holder 105 shown in Figures 8*a* and 8*b* has a conventional tapered bore 121 which tapers to the right (as seen in Figure 6) in an inclusive angle of, for example, 1° to

$1\frac{1}{2}°$: whilst on its outer surface are three helical grooves 145', 145'', 145''', of which Figure 6 shows only the groove 145'. A typical pitch for these helical grooves is 23 mm per 180°.

It will be seen that the drill bit 114, without its cutter 116, serves as a tool member carrying both the first and the second cutting means, viz. the various cutting edges of the bit 116. This is in contrast to the other embodiments described herein, in which there is provided a separate tool member carrying a second cutting means for boring the conical hole zone 13. In each of the embodiments described, however, the second cutting means is carried by a tool member whilst the first cutting means is carried by the tool body; this is the case in the embodiment of Figure 6 by virtue of the drill bit 114 itself being secured in the tool body by means of the holder 105.

As shown in Figure 9*a*, the tool body member 140 consists of a first or leading cylindrical portion 126, having the bore 142 formed eccentrically therein, and an integral thickened cylindrical portion 127 of larger outer diameter, having a blind bore 125 coaxial with the bore 142. The threads 137 aforementioned are formed in a portion of the bore 125 extending from the open end of the latter. The portion 126 has external helical grooves 128 for the discharge of bored-out material.

As seen in Figure 6, the drill bit holder 105 is supported in the eccentric bore 125 of the body member 140. The diameter of the bore 142 is the same as the greatest diameter of the drill bit holder bore 121, which occurs at the leading end of the latter nearest the bore 142. The bores 142 and 121 are thus continuous with, and aligned with, each other.

The larger portion 127 of the tool body member 140, as shown in Figure 9*a* and 9*b*, has three longitudinal slots 148', 148'', 148'''. As shown in Figure 6, the sleeve 147 carries three radial pins 146', 146'', 146''' which are rigidly fixed to the sleeve and extend inwardly thereof, to project through the respective slots 148', 148'', 148''' into the helical grooves 145', 145'', 145''' respectively of the drill bit holder 105 (Figure 8*b*). Thus, when the sleeve 147 is displaced axially with respect to the tool body member 140, the simultaneous displacement of the pins 146', 146'', 146''' rotates the holder 105 in the bore 125 and thus also rotates the drill bit 114 in the bore 142.

When the drill bit 114 is orientated with respect to the tool body member 140 in the manner shown in Figure 6, the axis of rotation *B—B* of the tool body 140, 106 intersects the leading point 119 of the drilling cutter 116. When the tool body is rotated about axis *B—B* with the drill bit 114 thus orientated, the axis *A—A* of the drill bit 114 describes a circular path at the radial distance *b* about the axis *B—B*. A drilling operation is then performed by first cutting means comprising the two main cutting edges 117' and 118' together with the secondary cutting edge 117; as can be seen from Figure 6, this is the situation during formation of the cylindrical hole zone 12.

If, however, the drill bit 114 is rotated with respect to the tool body 140, 106 by rotation of the drill bit holder 105 about its axis *A—A* in the bore 125, as described above, the radial distance from the tool body axis *B—B* of any point (e.g. point 120) on the cutting edges 118 and 118' is increased by an amount directly proportional to the angle through which the drill bit 114 has been rotated with respect to the tool body. Under these conditions the boring operation is performed by second cutting means comprising the cutting edges 118 and 118'. Thus is the situation during formation of the conical hole zone 13, as will be described hereinafter.

As can be seen by comparing Figures 6 and 10, the drill bit 114 is rotated through an angle of 180° between the retracted position (Figure 6) and the fully-extended position (Figure 10) of the second cutting means 118, 118', the leading point 119 being offset in the latter position by twice the distance *b* from the tool body axis *B—B*.

The actual cone angle defined by the zone 13 is of course determined by the relationship between the rotation of the drill bit 114 about its axis *A—A* and the corresponding axial movement of the tool body relative to the sleeve 147, and therefore by the pitch of the helical groove 145 of the drill bit holder 105.

The sleeve 147 carries a pressure ring 155 which is rotatably located thereon by a retaining ring 154. Bored-out material, led along the body member 140 by the helical grooves 128, is discharged through openings 153 in the sleeve 147.

The push rod 108 is accessible from the outside by way of two slots 139 and 139' in the body member 106. By conventionally driving a wedge (not shown) into the slots 139, 139', the push rod 108 can be forced to strike the end of the drill bit shank extension 113 to dislodge the drill bit 114 from its holder 105.

The tool body member 106 has a flange 150, and the spring 150 bears between the sleeve 147 and flange 151, to bias the tool body 140, 106 towards the relative position shown in Figure 6, in which the pins 146', 146'', 146''' abut against the inner or left-hand ends of the slots 148', 148'', 148'''.

A pin 143 engaging the flattened face 114' of the drill bit 114 to ensure the correct orientation of the latter in the holder 105 is, as shown in Figure 8*b*, mounted in a chordal hole 144 in the holder 105.

To drill a hole 11, the drill bit 114 is first inserted into the body member 140 and drill bit holder 105, in the orientation shown in Fig. 6, with the leading point 119 of the cutter 116 in the axis of rotation *B—B* of the drilling tool, and the outer circumference of

the body portion 126 in alignment both with the secondary cutting edge 117 and with the point 120 of the drilling cutter 116. The hole 11 is now formed with the drilling tool in continuous rotation about the axis *B—B*. The cylindrical hole zone 12 is now drilled out until the pressure ring 155 abuts against the surface 1′ of the wall 1. Thereafter, as the tool body member 140 advances further, the sleeve 147 compresses the spring 150, and the pins 146′, 146″, 146‴ rotate the drill bit holder 105 with respect to the body member 140; during this relative rotation the cutting edge 118 is moved radially outwards in the manner hereinbefore described, thus forming the conical hole zone 13.

The position of the drill bit 114 and body portion 126 at the end of the boring process is shown in Figure 10, which also shows the final shape of hole 11 as made by this particular embodiment of the drilling tool. In contrast to the hole 11 of Figure 1, the hole 11 in Figure 10 does not have a further cylindrical zone 14 joined to the conical zone 13; effective centring of the shaft 140, 106 during the whole drilling process, and particularly during boring of the zone 13, is achieved through the cylindrical body portion 126 engaging in the cylindrical hole zone 12. Fitting of an expansion plug as shown in Figure 2 in the hole 11 of Figure 10 takes place without an expanding tool. The expanding element (such as the element 22 in Figure 2) is introduced to abut on the blind end of the hole 11. The casing 21 is slidingly introduced up to the expanding element 22 and is then driven fully in by force. It thus slides over the expanding element and in this process is correspondingly expanded radially into the conical hole zone 13.

The modification shown in Figures 11 to 13 differs from the embodiment of Figures 6 to 10 by a different means for engagement of the actuating sleeve 147 with the drill bit holder, shown in Figure 12*a* and designated 205, which has axial straight grooves 245′, 245″, 245‴. Radial pins 246′, 246″ and 246‴, rigidly carried internally by the sleeve 147, are guided in helical slots 248′, 248″, 248‴ in a tool body member 240 (Fig. 13) which is otherwise as described with reference to Figures 6 to 10. The embodiment of Figures 11 to 13 is generally the same as that of Figures 6 to 10 in all other respects.

The drilling tool shown in Figures 14 and 15 includes a tool body or shaft 340 having at its outer end (i.e. the right-hand end in Figure 14) a cylindrical head 314 in which is a conical socket 350 for a mandrel or holder 348 which is held in the chuck (not shown) of a suitable drilling machine. The other (left-hand) end of the tool body 340 has a first cutting means in the form of a drilling cutter or bit 316 for drilling the cylindrical zones 12, 14 of a hole 11 (Figure 1). The tool body 340 has an arcuate slot 342 produced by milling out a crescent-shaped groove and subsequently inserting a covering member 308. A tool member in the form of an arcuate blade 353, movably mounted in the slot 342, has at its inner or left-hand end (as seen in Figure 14) a second cutting means in the form of a bit 341 which has a main cutting edge 341′ and a secondary cutting edge 341″. By displacement of the blade 353 along the slot 342, the bit 341 can be moved progressively to the position shown by dashed lines, so that the conical hole portion 13, of progressively increasing diameter depending on the radial position of the bit 341 with respect to the tool body axis *B—B*, can be bored by means of this bit 341.

A pin 346 is carried at the outer or right-hand end of the blade 353; this end projects radially outwards from the tool body 340. A longitudinally-displaceable actuating ring 347, having an outer sleeve 360, is mounted around, and for co-axial movement with respect to, the tool body 340, and has a radial recess 347′ for holding the radially-projecting end of the blade 353. The pin 346 is guided in two opposed chordal slots 345′ and 345″ extending in the actuating member 347 obliquely with respect to the longitudinal axis *B—B* of the tool body. A spring 350 is arranged between the member 347 and the head 314 of the tool body 340. A pressure ring 355 is secured rotatably around the sleeve 360 by a retaining ring 354. Actuating ring 347 and pressure ring 355 are provided with openings 359, 361 respectively for chip discharge.

The drilling tool of Figures 14 and 15 operates in largely the same manner as that shown in Figures 3 to 5, except that here the cylindrical hole zone 14 is again present. The drilling cutter 316 first forms the cylindrical zone 12 until the pressure ring 355 strikes the surface 1′; as the rotating tool body 340 advances further, it compresses the spring 350 against the actuating ring 347 so that, due to the engagement of the pin 346 in the slots 345′ and 345″, the bit 341 is pushed radially out of the slot 342. As it moves radially outwards, the conical hole zone 13 is bored, simultaneously with the drilling of the cylindrical hole zone 14 by the bit 316.

In the modification shown in Figure 16, the second cutting means and tool member associated therewith are combined in a blade 453 which has a cutting edge and is displaceable in a straight slot 442 in the tool body 440, by the engagement of pin 446, connected with the actuating ring 447 (corresponding to the ring 347 in Figure 14), in two slots of which only one slot, 445′, is shown. Two nuts 470 and 471 are screwed coaxially on to the actuating ring 447 such that, by being tightened against each other, they can be secured in a specific axial position so as to define the position of the pressure ring 455. The latter is rotatably mounted on the nut 470 by a ring 472. By axial adjustment of the nut 470 on the actuating ring 447,

compensation may be made for wear of the cutting edge of the blade 453.

The embodiment of Figure 17 differs from that of Figure 16 in that a tool member in the form of a cutter holder 553 is carried by the pin 446, the end of the holder 553 in the slot 542 having a conical socket 554 in which the second cutting means in the form of a bit 541, is secured and orientated by a pin 560 engaging a flattened area 561 of the shank of the bit 541.

It will be seen from the foregoing that with all the described embodiments, it is possible to drill in a single operation of the drilling tool a hole having a cylindrical zone 12 and a zone 13 joined thereto which extends divergently toward the rear of the hole.

The different embodiments described above are especially suitable for various different purposes. For example:—

(a) The embodiment of Figures 3 and 4 is suitable with larger hole diameters, for light construction materials (e.g. aerated concrete) as well as for heavy construction materials (e.g. reinforced concrete, solid stone). Especially advantageous is the support of the blade 43 in the slot 42 of the tool body 40; this support enables considerable forces to be exerted safely upon the blade 43;

(b) The embodiments of Figures 6 to 13 are suitable for hard materials which result in a very great wear, having regard to the easy replaceability of the drill bit 114, and to the fact that only one bit is required since the cylindrical, as well as the conical, hole zones are cut with the same bit. Where high torsion loads are liable to be exerted on the drill bit 114, these embodiments are especially suitable for smaller diameters, since any weakening induced by the interruption of the tool body by the slot 42 in Figure 3 is eliminated; and

(c) The embodiment of Figure 14 is suitable for small diameter holes in light materials.

It will be noted that in each of the embodiments described the leading portion of the tool body is supported, at least throughout the advance of the drilling tool into the hole whilst the conical hole zone 13 is being bored, laterally in the cylindrical zone 12 already drilled. As can be seen from Figures 5, 10 and 14, this is achieved by making the cross-section of the leading portion of the tool body such that it fits rotatably but relatively closely within the zone 12.

It will also be understood that during the boring of the conical hole zone 13, the second cutting means and its associated tool member (viz. blade 43 in Figure 5, drill bit 114 in Figure 10, and blades 353, 453, and 553 in Figures 14, 16 and 17 respectively) are constrained by the various portions of the tool body in which they are held so as to follow a predetermined path between the retracted and fully extended positions of the second cutting means (58, 118 etc). This constraint, and the inherent rigidity of these various tool members and cutting means, ensures that the conical zone is bored with an accuracy which is not impaired by any significant deflection of the tool member or cutting means due to the forces imposed thereon by the boring operation itself. The construction in each embodiment is such that these forces are transmitted back to the tool body; and because of the lateral support of the latter mentioned in the last preceding paragraph, the tool is prevented from being deflected by such forces from its straight drilling path along the tool body axis of rotation.

WHAT WE CLAIM IS:—

1. A drilling tool for drilling a hole of the kind hereinbefore specified, said tool comprising a tool body rotatable about an axis thereof; first cutting means carried by the tool body and adapted for drilling a cylindrical hole on said axis; a substantially rigid tool member carried by and rotatable with the tool body about said axis and having second cutting means, said tool member being arranged for movement with respect to the tool body between a retracted position of the second cutting means, wherein the seond cuting means defines about said axis no greater radius than does the first cutting means, and a fully extended position of the second cutting means, wherein the second cutting means defines a greater radius than does the first cutting means; and actuating means carried by the tool body and arranged to effect such movement of said tool member with respect to the body to move the second cutting means from its retracted to its fully-extended position in response to progressive advance of the tool body into a said hole from a predetermined axial position therein, whereby during such advance the second cutting means can bore a said divergent second zone of the hole, a leading portion of the tool body being of such cross-section as to be laterally supported on said axis in a said first zone of the hole behind the second cutting means during said advance, and said tool body having means for constraining said tool member in a predetermined path throughout the said movement of the tool member with respect to the body.

2. A tool according to Claim 1, wherein said actuating means and constraining means are adapted so that said movement of the tool member with respect to the tool body is rotational.

3. A tool according to Claim 2, wherein the tool member is arranged for said rotational movement in a plane containing the axis of the tool body.

4. A tool according to Claim 3, wherein the tool member is pivoted to the tool body

about a fixed transverse pivot axis.

5. A tool according to any one of the preceding claims, wherein the tool member is in the form of a blade having said second cutting means at one end thereof.

6. A tool according to Claim 5, wherein said blade is mounted in a through slot in the tool body.

7. A tool according to Claim 6, wherein said blade fits in the slot for movement along a path defined by the slot, so that the slot constrains the blade in said path throughout movement of the blade with respect to the tool body.

8. A tool according to Claim 6 or Claim 7, wherein the slot is arranged diametrally in the tool body.

9. A tool according to Claims 4 and 6, wherein the actuating means includes a blade-engaging member engaging an element of the pivoted blade in said slot, said blade-engaging member being movable longitudinally of the the tool body and said blade element being so orientated with respect to the tool body axis that the blade-engaging member in moving longitudinally will move the blade pivotally about its pivot axis, whereby the pivot axis and blade-engaging member also constrain the blade in an arcuate path with respect to the tool body.

10. A tool according to Claim 9, wherein the said blade element is a slot formed in the blade obliquely to the sol body axis, the blade-engaging member being a member projecting generally radially through a longitudinal slot in the tool body to engage in the blade slot.

11. A tool according to Claim 7, wherein the blade is secured only to the actuating means, being so secured at the end of the blade remote from the second cutting means.

12. A tool according to Claim 11, wherein the blade, and the slot in the tool body, are both arcuate, whereby said path of the blade with respect to the tool body is arcuate, the said slot terminating at both its ends on the same side of the tool body.

13. A tool according to Claim 11, wherein the through slot extends across the tool body obliquely to the tool body axis, whereby the second cutting means is at the side of the tool body opposite the end of the blade secured to the actuating means.

14. A tool according to Claim 13, wherein said through slot and said blade are both substantially straight, whereby said path of the blade with respect to the tool body is substantially straight.

15. A tool according to any one of Claims 5 to 14, wherein the second cutting means is integral with the blade.

16. A tool according to any one of Claims 5 to 14, wherein the second cutting means comprises a cutting bit secured to the blade.

17. A tool according to any one of the preceding claims, wherein the first cutting means is arranged on the tool body itself.

18. A tool according to Claim 17, wherein the first cutting means is integral with the tool body.

19. A tool according to Claim 17, wherein the first cutting means comprises a drilling cutter terminating at a point on the tool body axis.

20. A tool according to Claim 2, wherein said first and second cutting means are arranged in a single cutting member adapted for drilling a cylindrical hole on the axis of rotation of the tool body when the cutting member is orientated in a first angular position relative to the tool body, being the retracted position of the second cutting means, and for drilling a hole of progressively changing diameter when the angular orientation of the cutting member relative to the tool body is progressively changed between said first position and a second angular position being the fully-extended position of the second cutting means, the said cutting member being carried by said tool member, said tool member having an axis radially offset from the tool body axis and being mounted in the tool body for rotational movement about the said axis of the tool member, whereby to change said angular orientation.

21. A tool according to Claim 20, wherein the first cutting means comprises a leading cutting surface of the cutting member, the centre of said leading surface being radially offset from the axis of the tool member, and the second cutting means comprises a further cutting surface of the cutting member, the axis of the tool member being offset radially from that of the tool body by the same amount as from said centre, so that in said first angular position said centre lies on the tool body axis and in said second angular position, being 180 degrees from said first position, said centre is displaced radially from the tool body axis by twice the said amount.

22. A tool according to Claim 21, wherein the leading cutting surface is substantially V-shaped and comprises equal first and second primary cutting edges, joined at said centre in a leading point.

23. A tool according to Claim 22, wherein the cutting member has a first and a second secondary cutting edge extending backwards from the radial extremities of the first and second primary cutting edges respectively, the first secondary cutting edge being generally parallel with the tool member axis and the second secondary cutting edge being inclined backwards towards said axis, the said leading point being radially offset from the tool body axis on the same side thereof as the second secondary cutting edge, and the second cutting means comprising at least the second secondary cutting edge.

24. A tool according to Claim 23, wherein the second secondary cutting edge is inclined with respect to the tool body axis by an angle

corresponding to the angle of divergence of a conical hole zone bored thereby and defined by the rotational movement of the tool member with respect to the tool body by the actuating means in response to axial movement of the tool body.

25. A tool according to any one of Claims 20 to 24, wherein said cutting member is generally planar.

26. A tool according to any one of Claims 20 to 25, wherein said cutting member is a separate member carried by said tool member.

27. A tool according to any one of Claims 20 to 26, wherein said tool member is a removable drill bit, the tool being adapted for removal and replacement thereof.

28. A tool according to any one of Claims 20 to 27, wherein the tool member extends rotatably and longitudinally of the tool body through the leading portion of the tool body by which it is laterally supported, there being at the end of the tool member, remote from the cutting means, a rotatable element mounted coaxially with and within the tool body, said rotatable element being arranged to be rotated with respect to the tool body by the actuating means.

29. A tool according to Claims 27 and 28, wherein the said rotatable element is a drill bit holder having a bore, the axis of which is radially offset from, but parallel to, the axis of the drill bit holder and adapted to receive and hold the drill bit in predetermined angular orientation therewith.

30. A tool according to Claim 29, wherein the tool body has a bore extending rearwardly of said drill bit holder, and a push rod movable in said bore and accessible through at least one opening in the tool body such that force can be applied axially to the push rod to drive it against the end of the drill bit held in said holder, so as to dislodge the drill bit from the holder.

31. A tool according to any one of the preceding claims, wherein the actuating means includes an actuating member movable axially on the tool body and biasing means for biasing the actuating member towards a forward position on the body, the actuating member being operatively connected with said tool member to effect said movement of the tool member with respect to the tool body in response to relative axial movement between said actuating member and tool body, the actuating member being arranged to initiate said relative axial movement in response to the tool body reaching said predetermined axial position in a hole being drilled.

32. A tool according to Claim 31, wherein said actuating member comprises a sleeve or ring encircling a portion of the tool body.

33. A tool according to Claim 32, wherein said actuating member carries a coaxial pressure ring rotatable relative thereto, said pressure ring being so disposed with respect to the tool body, that in operation it engages an element in which a said hole is being bored, whereby to prevent the actuating member advancing with the tool body when the tool body reaches a said predetermined axial position.

34. A tool according to Claim 10 in combination with any one of Claims 31 to 33, wherein the blade-engaging member is carried by the actuating member.

35. A tool according to Claims 11 and 32 in combination, wherein the actuating member has a slot disposed obliquely to the tool body axis in a diametral plane, the appropriate end of the blade being secured to the actuating means by a slot-engaging member slidable along and within the slot in the actuating member, whereby relative axial movement between the actuating member and tool body displaces the slot-engaging member radially so as to move the blade along its said path with respect to the tool body.

36. A tool according to Claim 32, in combination with either Claim 28 or Claim 29, wherein the said sleeve or ring has at least one inward radial projection, extending through a first guide comprising an elongate guide opening in the tool body and engaging in a second guide comprising a groove formed on the said rotatable element, one of said guides being helical and the other parallel, with respect to the tool body axis, whereby axial movement of the sleeve or ring on the tool body from said forward position thereof causes the said radial projection to rotate the rotatable element so as to rotate the tool body from said first angular position of the cutting means towards said second angular position thereof.

37. A tool according to any one of the preceding claims, wherein said leading portion of the tool body is generally-cylindrical and of such diameter relative to the first cutting means as to fit slidingly in a cylindrical hole zone drilled by the first cutting means.

38. A tool according to Claim 37, wherein at least said leading portion of the tool body has external groove means adapted for the discharge of bored-out material therealong.

39. A tool according to Claim 32, wherein said sleeve or ring has openings for discharge of bored-out material therethrough.

40. A drilling tool constructed, arranged and adapted to operate substantially as hereinbefore described with reference to, and as illustrated in, Figures 3 to 5 of the accompanying drawings, for boring a hole of the kind hereinbefore specified in an element in a single operation.

41. A drilling tool constructed, arranged and adapted to operate substantially as hereinbefore described with reference to, and as illustrated in, Figures 6 to 10 (with or without the modification of Figures 11 to 13) of the accompanying drawings, for boring a hole of the kind hereinbefore specified in an element in a single operation.

42. A drilling tool constructed, arranged

and adapted to operate substantially as hereinbefore described with reference to, and as illustrated in, Figures 14 and 15 (with or without the modification of Figure 16 or the modification of Figure 17) of the accompanying drawings, for boring a hole of the kind hereinbefore specified in an element in a single operation.

43. A method of drilling in an element, in a single operation, a hole of the kind hereinbefore specified using a drilling tool according to any one of the preceding claims, said method comprising the steps of introducing the tool to the element; with the tool in continuous rotation about the tool body axis and the tool member in its retracted position, drilling the cylindrical first hole zone in the element by means of the first cutting means until the tool body has reached a predetermined axial position with respect to the element with a leading portion of the tool body laterally supported on said axis in said cylindrical first zone; and continuing rotation of the tool so that the actuating means thereafter progressively effects rotational movement of the said tool member with respect to the tool body from its retracted to its fully-extended position, so that during said continued rotation of the tool the second cutting means progressively bores out the divergent second hole zone with the tool body laterally supported on said axis in the cylindrical first zone.

44. A method, substantially as hereinbefore described with reference to Figures 1 to 5 of the accompanying drawings, for drilling a hole of the kind hereinbefore specified in an element in a single operation using a tool according to Claim 40.

45. A method, substantially as hereinbefore described with reference to Figures 1, 2 and 6 to 10 of the accompanying drawings, for drilling a hole of the kind hereinbefore specified in an element in a single operation, using a tool according to Claim 41.

46. A method, substantially as hereinbefore described with reference to Figures 1, 2, 14 and 15 of the accompanying drawings, for drilling a hole of the kind hereinbefore specified in an element in a single operation, using a tool according to Claim 42.

47. An element having a hole drilled therein by a method according to any one of Claims 43 to 46.

48. An element according to Claim 47 being a constructional element.

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Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1976.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

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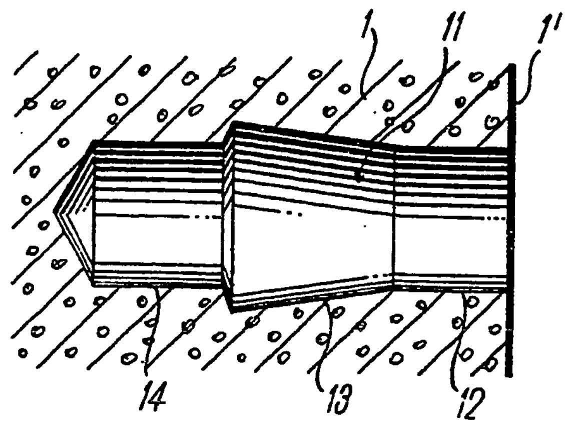

Fig.1

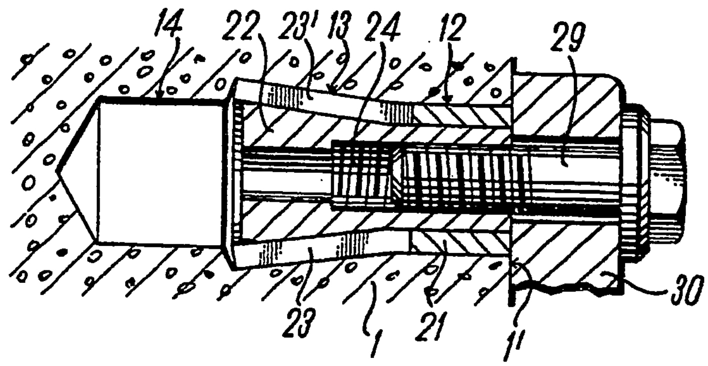

Fig.2

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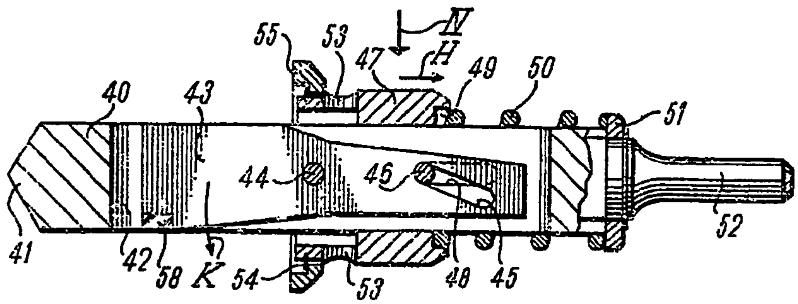


Fig. 3

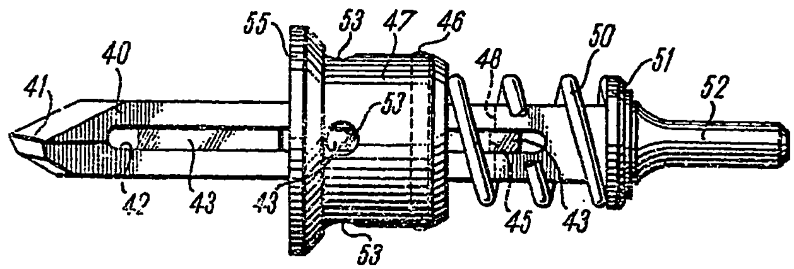


Fig. 4

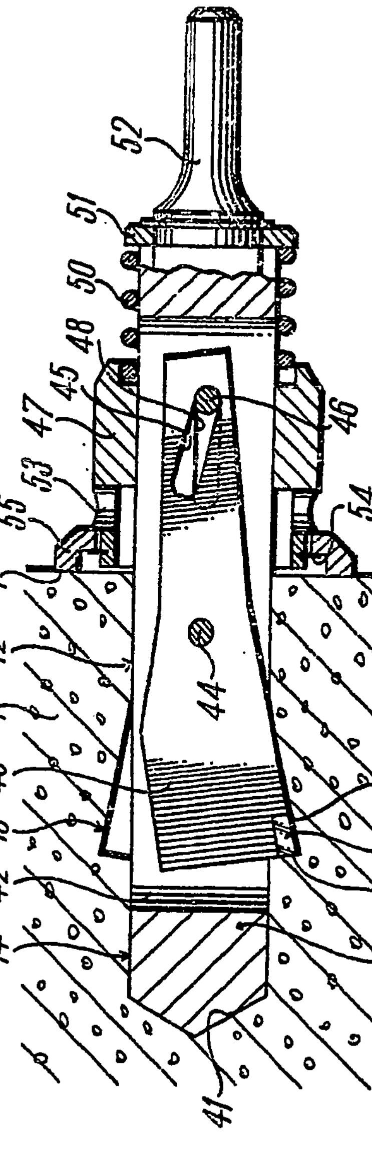


Fig. 5

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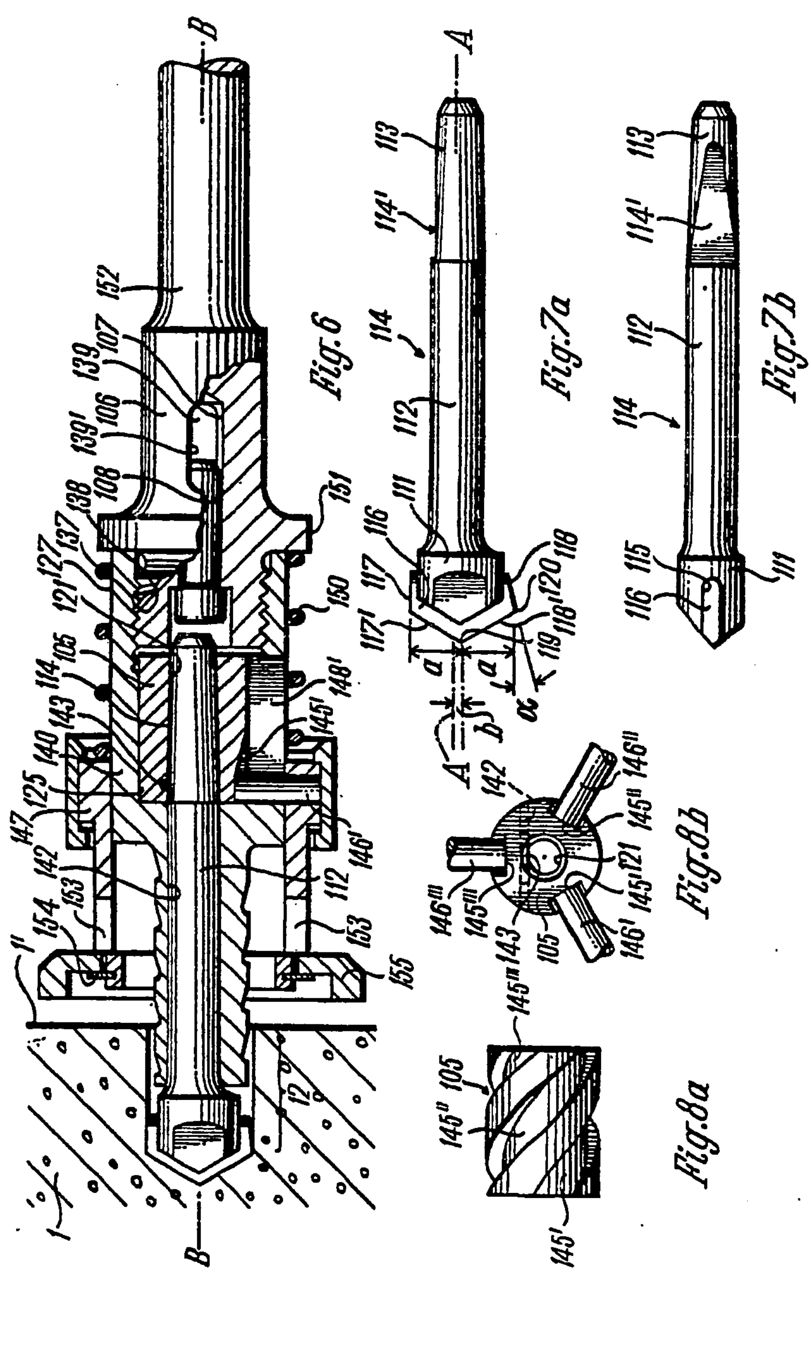

Fig. 6

Fig. 7a

Fig. 7b

Fig. 8a

Fig. 8b

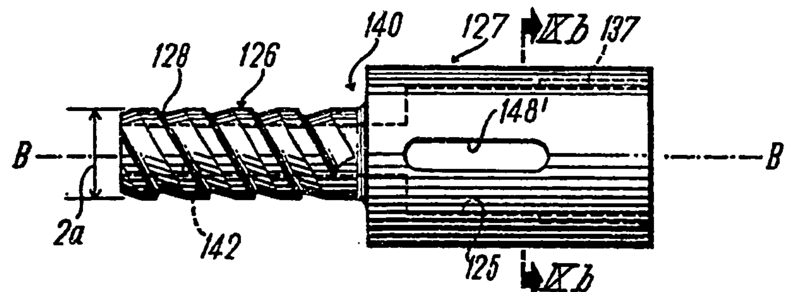


Fig. 9a

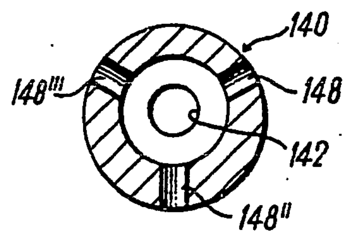


Fig. 9b

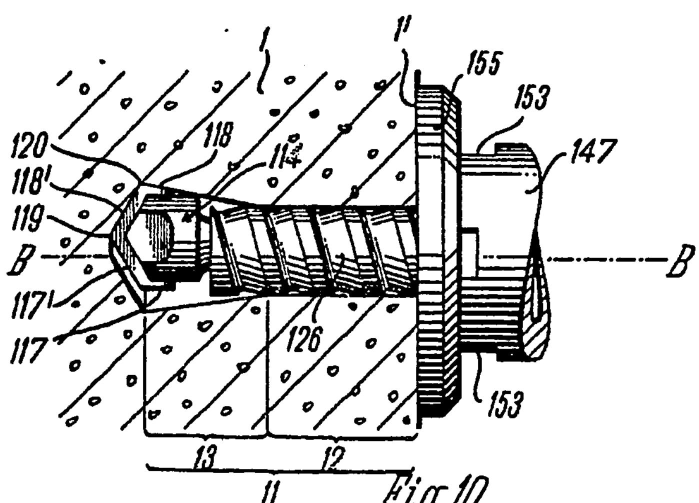


Fig. 10

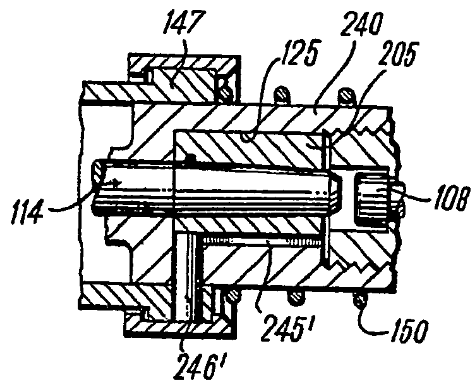


Fig.11

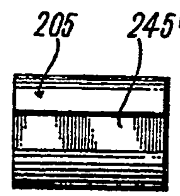


Fig.12a

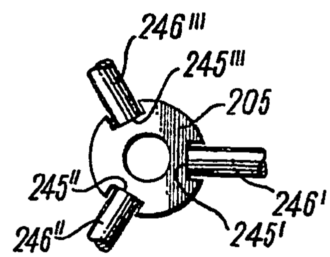


Fig.12b

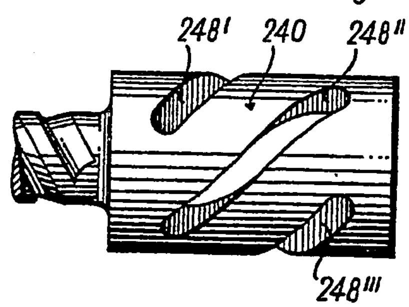


Fig.13

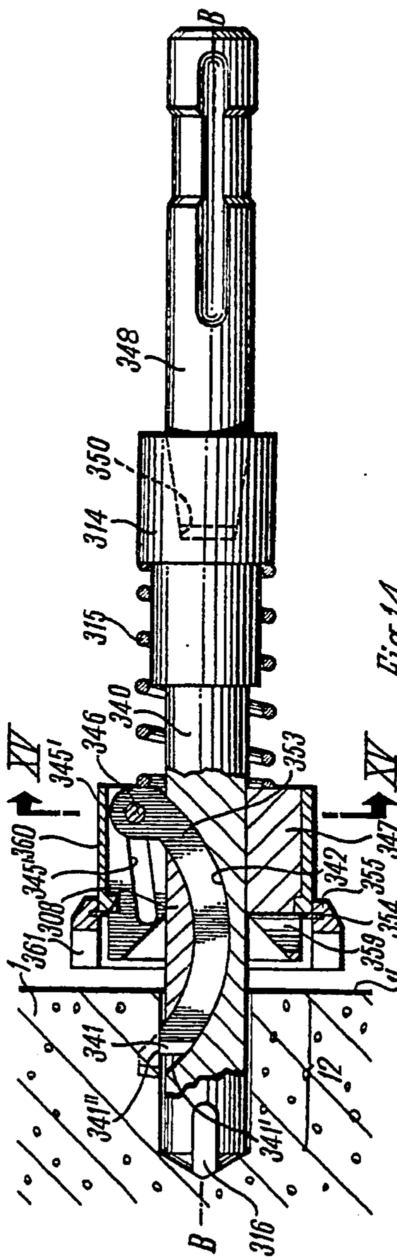
B
348
350
314
315
340
346
345'
XV
353
XV
360
345
308
361
342
355
347
354
359
1'
1
341
341''
341''
12
316
B

Fig.14

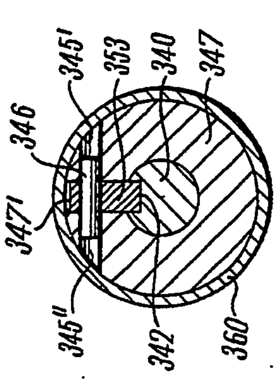
346
345'
353
340
347
347'
345''
342
360

Fig.15

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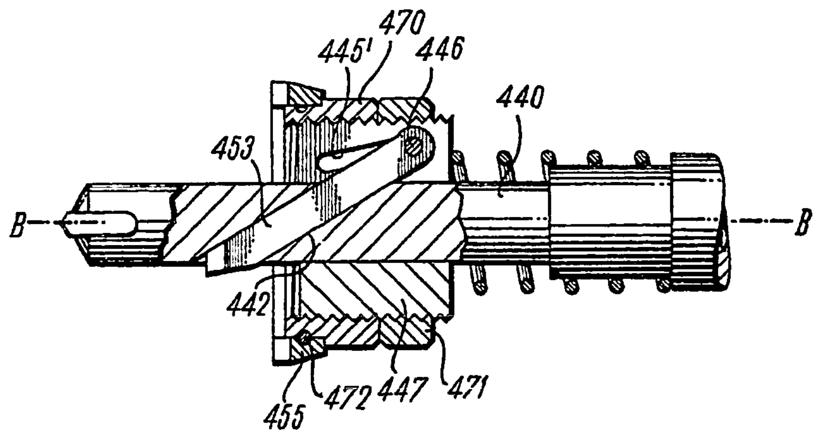


Fig.16

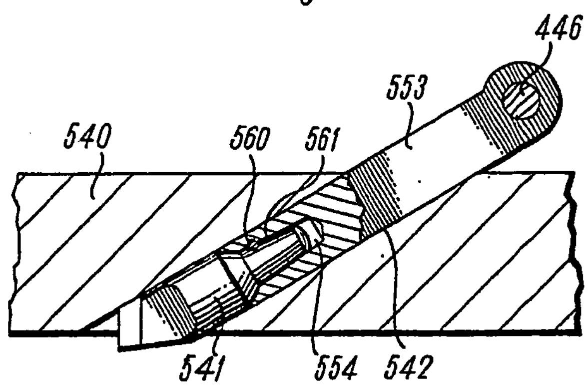


Fig.17